

AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions and listings of claims in the application:

LISTING OF CLAIMS:

1-8. (canceled).

9. (previously presented): A method of manufacturing an ink-jet printing head, comprising the steps of:

forming a plurality of channels in one side of a silicon monocrystalline substrate;

forming an oscillating plate film on the bottom of each channel;

forming a piezoelectric thin-film element which comprises a piezoelectric film sandwiched between upper and lower electrodes, on the oscillating plate film; and

forming pressurizing chambers in the opposite side of the silicon monocrystalline substrate so as to be opposite to the channels, respectively,

wherein the forming step of the piezoelectric thin-film element comprises the steps of:

forming the lower electrode;

forming the piezoelectric film on the lower electrode;

forming the upper electrode on the piezoelectric film; and

removing a portion of the upper electrode to make an effective width of the upper electrode narrower than an width of the pressurizing chamber.

10. (original): The manufacturing method for the ink-jet printing head according to claim 9, wherein the forming step of the piezoelectric thin-film element comprises the steps of:

forming a piezoelectric film precursor; and

subjecting the piezoelectric film precursor to a heat treatment in an atmosphere including oxygen so as to change the piezoelectric film precursor to the piezoelectric film.

11. (original): The manufacturing method for the ink-jet printing head according to claim 9, wherein the removing step comprises the steps of:

forming a pattern of etching mask material which acts as a mask to an etching substance, in the areas of the upper electrode which are desired to leave; and

etching away the areas of the upper electrode that are not covered with the etching mask material.

12. (original): The manufacturing method for the ink-jet printing head according to claim 9, wherein, wherein removing step of:

removing a portion of the upper electrode by irradiating the areas of the upper electrode desired to remove with using a laser beam.

13-16. (canceled).

17. (previously presented): A method of manufacturing an ink-jet printing head having a plurality of pressurizing chamber substrates formed on a silicon monocrystalline substrate, each pressurizing chamber substrate having a plurality of pressurizing chambers formed on one side thereof, comprising the steps of:

partitioning the silicon monocrystalline substrate into unit areas to be used in forming the pressurizing chamber substrates, and

forming only one recess in the side of the pressurizing chamber substrate in which the pressurizing chambers are to be formed, for each unit area, so as to leave a peripheral area along the circumference of the recess; and

further forming the pressurizing chambers in the recess formed in the recess making step, and

making the thickness of the peripheral area of the pressurizing chamber substrate greater than the height of a side wall for separating the pressurizing chambers from each other.

18. (previously presented): A method of manufacturing an ink-jet printing head having a plurality of pressurizing chamber substrates formed on a silicon monocrystalline substrate, each pressurizing chamber substrate having a plurality of pressurizing chambers formed on one side thereof, comprising the steps of:

partitioning the silicon monocrystalline substrate into unit areas to be used in forming each of the pressurizing chamber substrates,

forming the pressurizing chambers in the side of each of the pressurizing chamber substrates in which the pressurizing chambers are to be formed, while leaving a peripheral area along the circumference of the unit area; and

prior to forming the pressurizing chambers, forming a recess in the area of each of the pressurizing chamber substrates where the pressurizing chambers are to be formed,

wherein the thickness of the peripheral area of the pressurizing chamber substrate is greater than the height of a side wall for separating the pressurizing chambers from each other.

19. (currently amended): A method of manufacturing an ink-jet printing head having a plurality of pressurizing chamber substrates formed on a silicon monocrystalline substrate, each pressurizing chamber substrate having a plurality of pressurizing chambers formed on one side thereof, comprising the steps of:

partitioning the silicon monocrystalline substrate into unit areas to be used in forming each of the pressurizing chamber substrates, and

for each of the pressurizing chamber substrates, forming only one recess in the side of the pressurizing chamber substrate opposite to the side on which the pressurizing chambers are formed in each unit area, while leaving a peripheral area along the circumference of the unit area, wherein the mechanical strength of the silicon monocrystalline substrate is maintained by increasing making the thickness of the pressurizing chamber substrate in the peripheral area greater than the thickness of the pressurizing chamber substrate in the recess.

20. (currently amended): A method of manufacturing an ink-jet printing head having a plurality of pressurizing chamber substrates formed on a silicon monocrystalline substrate, each pressurizing chamber substrate having a plurality of pressurizing chambers formed on one side thereof, comprising the steps of:

making a recess including the steps of,

partitioning the silicon monocrystalline substrate into unit areas to be used in forming the pressurizing chamber substrate,

forming a recess in the side of the pressurizing chamber substrate opposite to the side on which the pressurizing chambers are formed in each unit area, while leaving a peripheral area along the circumference of the unit area, wherein the mechanical strength of the silicon monocrystalline substrate is maintained by ~~increasing~~making the thickness of the pressurizing chamber substrate in the peripheral area greater than the thickness of the pressurizing chamber substrate in the recess,

forming a layer to be processed;

providing the layer to be processed with a resist and patterning the resist;

etching the layer to be processed corresponding to the recess masked in the resist mask formation step;

further etching the area of the silicon monocrystalline substrate from which the layer to be processed has been removed as a result of the etching step; and

forming a layer to be processed in the recess etched in the recess etching step.

EX PARTE QUAYLE AMENDMENT

U.S. Application No. 09/599,440

Attorney Docket No. Q59177

21. (currently amended): A method of manufacturing an ink-jet printing head having a plurality of pressurizing chamber substrates formed on a silicon monocrystalline substrate, each pressurizing chamber substrate having a plurality of pressurizing chambers formed on one side thereof, comprising the steps of:

making a recess including the steps of,

partitioning the silicon monocrystalline substrate into unit areas to be used in forming the pressurizing chamber substrate, and

forming a recess in the side of the pressurizing chamber substrate opposite to the side on which the pressurizing chambers are formed in each unit area, while leaving a peripheral area along the circumference of the unit area, wherein the mechanical strength of the silicon monocrystalline substrate is maintained by ~~increasing~~ making the thickness of the pressurizing chamber substrate in the peripheral area greater than the thickness of the pressurizing chamber substrate in the recess,

forming a piezoelectric thin film sandwiched between electrode layers, in the recess formed in the recess forming step;

forming a resist on the piezoelectric ~~thin film~~ thin film formed in the piezoelectric thin-film forming step, by a resilient roller;

exposing the silicon monocrystalline substrate having the resist formed thereon in the resist forming step;

developing the silicon monocrystalline substrate exposed in the exposing step;

etching the piezoelectric thin film having the resist formed thereon in the developing step,
so as to form a piezoelectric thin-film element; and

forming the pressurizing chambers on the other side of the silicon monocrystalline
substrate so as to correspond to the piezoelectric thin-film elements formed in the etching step.

22. (previously presented): The manufacturing method for the ink-jet printing head
according to any one of claims 20 through 21, further comprising the step of:

separating the recess that does not include the peripheral area from the silicon
monocrystalline substrate so as to individually separate the pressurizing chamber substrates,
when the pressurizing chamber substrate is separated from each unit area after the pressurizing
chamber substrates have been formed.

23. (currently amended): The manufacturing method for the ink-jet printing head
according to any one of claims 20 through 21, further comprising the step of:

separating the pressurizing chamber substrates from the silicon ~~monocrystalline~~
monocrystalline substrate so as to include the peripheral area, so that the pressurizing chamber
substrates are individually separated from each other, when the pressurizing chamber substrate is
separated from each unit area after the pressurizing chamber substrates have been formed.

24-47. (canceled).

EX PARTE QUAYLE AMENDMENT

U.S. Application No. 09/599,440

Attorney Docket No. Q59177

48. (previously presented): A method of manufacturing an ink-jet printing head having a pressurizing chamber substrate formed with a plurality of other pressurizing chamber substrates on a wafer, each pressurizing chamber substrate having a plurality of pressurizing chambers formed on one side thereof, comprising the steps of:

forming only one recess in a first side of the wafer in which the pressurizing chambers are to be formed, so as to leave a peripheral area along the circumference of the recess;

partitioning the wafer into unit areas to be used in forming each pressurizing chamber substrate, and

for each partitioned unit area, forming the pressurizing chambers in that part of the recess corresponding to the partitioned unit area.

49. (previously presented): The manufacturing method for the ink-jet printing head according to claim 48, wherein the wafer is a silicon monocrystalline substrate.

50. (previously presented): The manufacturing method for the ink-jet printing head according to claim 48, wherein the wafer has a thickness of approximately 300 μm .

51. (previously presented): The manufacturing method for the ink-jet printing head according to claim 48, wherein the wafer has a diameter d , such that 4 inches $\leq d \leq$ 8 inches.

EX PARTE QUAYLE AMENDMENT

U.S. Application No. 09/599,440

Attorney Docket No. Q59177

52. (currently amended): A method of manufacturing an ink-jet printing head having a plurality of pressurizing chamber substrates formed on a silicon monocrystalline substrate, each pressurizing chamber substrate having a plurality of pressurizing chambers formed on one side thereof, comprising the steps of:

making a recess formation including the steps of,

partitioning the silicon monocrystalline substrate into unit areas to be used in forming the pressurizing chamber substrate, and

forming a recess in the side of the pressurizing chamber substrate in which the pressuring chambers are to be formed, for each unit area, so as to leave a peripheral area along the circumference of the recess; and

making a pressurizing chamber formation including the steps of,

further forming the pressurizing chambers in the recess formed in the step of forming the recess-making step, and

making the a thickness of the peripheral area of the pressurizing chamber substrate greater than the height of a side wall for separating the pressurizing chambers from each other,

wherein the recess that does not include the peripheral area is separated from the silicon monocrystalline substrate so as to individually separate the pressurizing chamber substrates, when the pressurizing chamber substrate is separated from each unit area after the pressurizing chamber substrates have been formed.

EX PARTE QUAYLE AMENDMENT

U.S. Application No. 09/599,440

Attorney Docket No. Q59177

53. (currently amended): A method of manufacturing an ink-jet printing head having a plurality of pressurizing chamber substrates formed on a silicon monocrystalline substrate, each pressurizing chamber substrate having a plurality of pressurizing chambers formed on one side thereof, comprising the steps of:

making a recess formation including the steps of,

partitioning the silicon monocrystalline substrate into unit areas to be used in forming the pressurizing chamber substrate, and

forming a recess in the side of the pressurizing chamber substrate in which the pressuring chambers are to be formed, for each unit area, so as to leave a peripheral area along the circumference of the recess; and

making a pressurizing chamber formation including the steps of,

further forming the pressurizing chambers in the recess formed in the step of forming the recess-making step,

making ~~the~~ a thickness of the peripheral area of the pressurizing chamber substrate greater than the height of a side wall for separating the pressurizing chambers from each other, and

wherein the pressurizing chamber substrates are separated from the silicon ~~monocrystalline~~ monocrystalline substrate so as to include the peripheral area, so that the pressurizing chamber substrates are individually separated from each other, when the pressurizing chamber substrate is separated from each unit area after the pressurizing chamber substrates have been formed.

54. (currently amended): A method of manufacturing an ink-jet printing head having a plurality of pressurizing chamber substrates formed on a silicon monocrystalline substrate, each pressurizing chamber substrate having a plurality of pressurizing chambers formed on one side thereof, comprising the steps of:

making a pressurizing chamber including the steps of,

partitioning the silicon monocrystalline substrate into unit areas to be used in forming the pressurizing chamber substrate, and

forming pressurizing chambers in the side of the pressurizing chamber substrate in which the pressuring chambers are to be formed, while leaving a peripheral area along the circumference of the unit area; and

making a recess including the steps of,

further forming a recess in the area where the pressurizing chambers are formed in the pressurizing chamber formation step, and

making ~~the~~ a thickness of the peripheral area of the pressurizing chamber substrate greater than the height of a side wall for separating the pressurizing chambers from each other,

wherein the recess that does not include the peripheral area is separated from the silicon monocrystalline substrate so as to individually separate the pressurizing chamber substrates, when the pressurizing chamber substrate is separated from each unit area after the pressurizing chamber substrates have been formed.

55. (currently amended): A method of manufacturing an ink-jet printing head having a plurality of pressurizing chamber substrates formed on a silicon monocrystalline substrate, each pressurizing chamber substrate having a plurality of pressurizing chambers formed on one side thereof, comprising the steps of:

making a pressurizing chamber including the steps of,

partitioning the silicon monocrystalline substrate into unit areas to be used in forming the pressurizing chamber substrate, and

forming pressurizing chambers in the side of the pressurizing chamber substrate in which the pressuring chambers are to be formed, while leaving a peripheral area along the circumference of the unit area; and

making a recess including the steps of,

further forming a recess in the area where the pressurizing chambers are formed in the pressurizing chamber formation step,

making ~~the~~ a thickness of the peripheral area of the pressurizing chamber substrate greater than the height of a side wall for separating the pressurizing chambers from each other,

wherein the pressurizing chamber substrates are separated from the silicon ~~monocrystalline~~ monocrystalline substrate so as to include the peripheral area, so that the pressurizing chamber substrates are individually separated from each other, when the pressurizing chamber substrate is separated from each unit area after the pressurizing chamber substrates have been formed.

56. (currently amended): A method of manufacturing an ink-jet printing head having a plurality of pressurizing chamber substrates formed on a silicon monocrystalline substrate, each pressurizing chamber substrate having a plurality of pressurizing chambers formed on one side thereof, comprising the steps of:

making a recess including the steps of,

partitioning the silicon monocrystalline substrate into unit areas to be used in forming the pressurizing chamber substrate, and

forming ~~a~~the recess in the side of the pressurizing chamber substrate opposite to the side on which the pressurizing chambers are formed in each unit area, while leaving a peripheral area along the circumference of the unit area, wherein the mechanical strength of the silicon monocrystalline substrate is maintained by ~~increasing~~making the thickness of the pressurizing chamber substrate in the peripheral area greater than the thickness of the pressurizing chamber substrate in the recess,

wherein the recess that does not include the peripheral area is separated from the silicon monocrystalline substrate so as to individually separate the pressurizing chamber substrates, when the pressurizing chamber substrate is separated from each unit area after the pressurizing chamber substrates have been formed.

57. (currently amended): A method of manufacturing an ink-jet printing head having a plurality of pressurizing chamber substrates formed on a silicon monocrystalline substrate,

each pressurizing chamber substrate having a plurality of pressurizing chambers formed on one side thereof, comprising the steps of:

making a recess including the steps of,

partitioning the silicon monocrystalline substrate into unit areas to be used in forming the pressurizing chamber substrate, and

forming ~~a~~the recess in the side of the pressurizing chamber substrate opposite to the side on which the pressurizing chambers are formed in each unit area, while leaving a peripheral area along the circumference of the unit area, wherein the mechanical strength of the silicon monocrystalline substrate is maintained by ~~increasing~~making the thickness of the pressurizing chamber substrate in the peripheral area greater than the thickness of the pressurizing chamber substrate in the recess,

wherein the pressurizing chamber substrates are separated from the silicon ~~monocrystalline~~monocrystalline substrate so as to include the peripheral area, so that the pressurizing chamber substrates are individually separated from each other, when the pressurizing chamber substrate is separated from each unit area after the pressurizing chamber substrates have been formed.